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Hybrid Energy and Bandwidth Management for Cognitive Radio on Cloud Data Centers

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Abstract: *Cloud data centers shares the storage space with the data providers. Wireless infrastructures are used for data center access. Communication bandwidth is shared between the cloud users. Smart grids are used to manage power, information and security services.*

Cloud computing data center is used as the central communication and optimization infrastructure. Cognitive radio network of AMI meters supports wireless transmission on the cloud environment. Net book advance metering infrastructure (Net-AMI) is used for wireless communication. The Net-AMI is a low cost infrastructure of AMI meters. Netbooks are operated with wireless transceiver. Netbooks uses cloud data center energy services, cognitive radio services and wireless communication services. Cognitive radios channels are used for the Net-AMI. Smart grid systems are constructed with Net-AMI models to share the cloud infrastructure under wireless environment. Smart grid supports software upgradable services for the cloud users. Link analysis is performed to schedule downlink and uplink Net-AMI packets in multiuser cognitive radio environment. The system can handles thousands of variations in power systems, communication protocols, and control and energy optimization protocols. Radio frequency (RF) and fiber optic communication models are used in the system.

The proposed system is designed to manage cloud data centers with wireless communication model. Energy and bandwidth management models are integrated with the Net-AMI scheme. Pricing schemes are included for bandwidth and data sharing process. Priority based bandwidth allocation is integrated in the wireless communication process.

1. INTRODUCTION

The Smart grid of the future is generally anticipated to consist of an intelligent energy delivery system that supports plug-and-play integration of power, information and security services. The future smart grid should possess a wide range of attributes that enable it to cope with information delivery, power flow distribution, intermittent energy sources, transmission line failures, energy storage systems, command and control of national infrastructure to achieve peak efficiency. In addition, as critical infrastructure it supports commerce and service needs. Resiliency and persistency in the aftermath of a major disruption is of the utmost importance to minimize economic disturbances. Future services will involve autonomous control of smart appliances, real time pricing adaptation, shifting grid-tied power usage to nonpeak periods, renewable energy management, and closed loop demand response. The services should be supportive of high penetrations of renewable energy components. It also acts as platform for consumer engagement in load management, national energy independence, and economic security [1]. In many such scenarios services, the advanced metering infrastructure (AMI) system is a central access point for communication of information flows in the smart grid and micro-grid distribution system networks.

We describe a new flexible Net-AMI infrastructure that supports the distributed smart grid. The Net-AMI network in the smart grid realm can be connoted as the firmware analogous to the PC Net books, but integrated to the realm Net-AMI infrastructure. In addition, in our model of the processing, public and private energy services reside in customer accessible cloud data center containing remote servers. The cloud offers other services such as demodulation of home area network protocols. Moreover, it also hosts energy manager applications with all the optimization algorithms residing in the cloud. It also provides micro grid energy optimization and other control services. Net-AMI meters behave akin to a message relay and storage with a modicum of processing capabilities and communication and wireless interfaces. Rather than full fledged intelligent control processing devices, the Net-AMI is optimized for carrying out control tasks, accessing power system information in buildings and home area networks, and relaying data whose fundamental processing occurs in cloud data centers.

We define an ideal Net-AMI meter network attributes as: 1) low cost infrastructure that is simultaneously rapidly deployable and can communicate wirelessly to a metropolitan wide network; 2) supports a universal set of protocols, standards, including most wireless and proprietary standards; 3) an ability to extensively adapt to future protocols via software upgrades; and 4) persistent power information flows of building usage and control, especially during power line disruption. It should also persist if a service provider exits the market, a customer lacks paid services, or new proprietary protocols emerge relative to the AMI meter. A conventional approach to AMI networking involves connectivity to an Ethernet network.

However, not every home or building supports Ethernet. In this paper, we propose a persistent, low cost infrastructure enabling a distributed metropolitan area network of wireless Net-AMI meters supportive of attributes 1–4. The network of Net-AMI meters is capable of cellular-like communications and control interactions with utility providers, mobile customers and autonomous energy management systems. Low cost and low latency infrastructure results from leveraging the modern cellular networks base transceiver station (BTS) tower footprint to support metropolitan area Net-AMI meter coverage areas. Low cost also results from integrating existing cellular BTS towers with new Net-AMI antennas supportive of wireless metropolitan area Net-AMI networking. We employ cognitive radio as an integrated component of the smart grid [9]. We place new cognitive radio antennas on existing cellular antenna towers to leverage their infrastructure and tower height to achieve vast geographical coverage. We proffer that wireless communication enables dynamic connectivity. In addition, remote software upgrades allow modifications of existing networks components and Net-AMI meters in a flexible, amorphous manner.

2. PERSISTENT NET-AMI NETWORKING

2.1. Cloud Data Center System Model

The energy services of the future can be privately contracted services or public services. The centralized energy services manager resides on a cloud computing data center. The cloud center enables convenient, on-demand network access to a shared pool of configurable, computing resources that can be rapidly provisioned and released with minimal management effort [2]. Cloud computing improves the availability of computing resources for wide varieties of software services. For instance, it can provide self-help services without the need for any manual interactions with service providers [3]. In our scenario of wireless cloud services, elasticity plays vital role due to high variations in the rate of users change accessing services. Cloud system services can reside far from physical locations of users.

There are different cloud computing platform classifications. Standard architectures include Abi, Nimbus Open Nebula, Azure, Google, Blue and Mosso. The model depict for a cloud data center architecture optimized for microgrid based smart grids. Microgrids can act as an island with a set of loads, energy storage, and dynamic adjustable capability which can be detached from grid-tied power. The layered design of microgrid architecture is formulated on the bases from currently existing cloud architecture but extrapolated with a new additional layer of communication and networking as a service. Our microgrid cloud is layered into four layers. They are application layer, platform layer, Communication and Networking Layer and Infrastructure Layer.

2.2. Data Center Based Microgrids and Smartgrids

Microgrids are envisaged as crucial infrastructure with a need for high levels of resiliency. Smart grid data in the cloud is obtained from various sources such as home area networks (HAN), AMI meters, transmission lines, distribution lines and vast arrays of sensor networks. Data obtained from these sources directly alter time varying consumption and generation. Our model uses a robust, scalable data centric system. Data is stored in the form of key-value pairs. The key can be the ID number of net-AMI meter or the time stamp. The value is the data associated with the key. Both the storage and retrieval is performed using keys. Flexibility is the key attribute for data centric system, which enables distributed data management and leads to horizontally scalable system. To enable redundancy, we can configure the number of replicas of any critical data with networked cloud centers. Moreover, as we rely on cloud centers to deliver critical services, system outage probabilities must be minimized. During network outages or environmental disturbances, the outage event service applications will shift the distribution equilibrium of the power system network via high speed control links to on distributed cloud resources.

In our model, we also achieve resiliency by integrating robust *cellular-like* services which are independent of cellular infrastructure and operated by utility-based network service providers. Cloud computing centers are designed to be scalable and to process large varieties of software applications. Finally, thought the total power required by cloud computing systems is not insignificant, many approaches to minimizing power involving adaptive prediction algorithms to achieve optimal task allocation, minimum resource utilization, and optimum energy dissipation workloads have been proposed in [5] and [4].

2.3. Core Cognitive Radios Model

Cognitive radio networks (CRN) for advanced Net-AMI infrastructure enable persistent operation independent of spectral band license ownership arrangements. Persistence results from opportunistic barrowing of unused spectrum. Traditional CRN include three primary components: spectrum sensing, spectrum management and spectrum sharing. In cognitive radio systems, the licensed user of the frequency band is always given priority access to the shared channel. Due to their priority in spectrum access, the operations of primary users (PU) are always first in the transmission queue so as to not be affected by unlicensed users. In our model of persistent Net-AMI wireless networking, the CRN is not required to have a license to operate in the desired spectrum. As a result, additional functionality is needed for CRN users to share the licensed spectrum band. We use a logical feedback channel model from a cognitive radio service running on a cloud data center. This is relayed to a cognitive radio antenna. In this way the Net-AMI schedules uplink transmission after the cognitive radio antenna transmits a downlink clear to send (CTS) signal. In this event, the Net-AMI transmits an uplink signal over the allocated CRN band. We presume procedures similar to [10].

3. PROBLEM STATEMENT

Cloud computing data center is used as the central communication and optimization infrastructure. Cognitive radio network of AMI meters supports wireless transmission on the cloud environment. Net book advance metering infrastructure (Net-AMI) is used for wireless communication. The Net-AMI is a low cost infrastructure of AMI meters. Netbooks are operated with wireless transceiver. Netbooks uses cloud data center energy services, cognitive radio services and wireless communication services. Cognitive radios channels are used for the Net-AMI. Smart grid systems are constructed with Net-AMI models to share the cloud infrastructure under wireless environment. Smart grid supports software upgradable services for the cloud users. Link analysis is performed to schedule downlink and uplink Net-AMI packets in multiuser cognitive radio environment. The system can handles thousands of variations in power systems, communication protocols, and control and energy optimization protocols. Radio frequency (RF) and fiber optic communication models are used in the system. The following drawbacks are identified from the system.

- Energy management models are not considered
- Pricing scheme is not included
- Bandwidth allocation is not optimized
- Low bandwidth utilization

4. COGNITIVE RADIO NET-AMI NETWORK SYSTEMS

We now describe the procedure for communicating data from the mobile user to an in building network controllable by the Net-AMI. This infrastructure enables true metropolitan areas wireless via Net-AMI meter networking. In this scenario the Net-AMI meter is not formally registered with any wireless service provider. We note that the procedure enables the adoption of a new style of universal interface methodology and bounds allowing wireless connectivity among the Net-AMI meter, mobile, and the utility. Cognitive radio enables wireless connectivity between mobile user and Net- AMI. Placement of a cognitive radio antenna (CRA) on the BTS tower may occur in tandem with deployment of the cellular provider antenna. Antenna placement can also occur on utility based tower sites. By deploying CRA on existing towers, we reduce the infrastructure cost. The CRA also maintains significant antenna height, thereby reducing the path loss. Furthermore, placement of CRA on high towers sites maximize cognitive radio sensing for spectrum management services. We define sensing as the combination of signal detection and modulation classification.

The cognitive radio (CR) senses the spectral environment over a wide frequency band, particularly the spectrum in the cell region. It identifies the unused bands in the spectrum. These bands could be owned by cellular companies or license television band owners, but are not limited to these bands or to licensed bands. Sensed information using the CR is relayed over the fiber to cloud data center. The data center then unrolls in order: the cognitive radio service, waveform service, protocols service, security service, microgrid information packet and air interface service, and the microgrid energy optimization or control services. The cloud center generates a response signal which is communicated over ROF to Net-AMI through CRA. Based on the incoming query, the Net-AMI performs several actions and a uplink transmission back to cloud center via ROF through CRA. The cloud center processes and analyzes Net-AMI data to generate a control signal to Net-AMI for using in building device control.

The flow of connection for the cognitive radio downlink presuming there is no subscription to high QoS energy management services running over cellular. In this scenario, the cognitive radio indentifies unused frequency bands, identifies the relevant cognitive services residing in the cloud data center, and generates a CTS signal. The CTS is sent back to the CRA through the feedback channel via radio over fiber links. Eventually, the CRA relays CTS signals to every Net-AMI meter in the cell region of CRA for uplink transmission.

A CTS signal accommodates both acknowledgment packets to send data from the Net- AMI meter and frequency band to transmit the signal and various other packets for over the air transmission. The Net-AMI responds to the CTS signal by sending the HAN data to CRA over the particular frequency band dedicated at this particular instant. The CRA receives the signal and forwards it via radio over fiber link to cloud data center. The cloud data center performs RF down conversion, A/D conversion and enables a plethora of Net-AMI communication standards, including proprietary utility standards.

Typically, the Net-AMI might need to interact with standards driven protocols such as GSM, LTE, HSPA, or WiFi rather than the Net-AMI meter's native communication protocol. Serendipitously, the cloud easily enables global aggregation of different protocols; it is capable of identifying the suitable protocols and supporting software definable radio wireless services. It then applies Net-AMI meter protocol services.

The rationale of this convergence of processing in the cloud is the ability for flexible, on demand processing enabled by cloud computing. Migration of protocols and software allows for concurrent support of legacy standards and future standards defined after the Net-AMI *firmware* systems are designed. Let us consider a scenario where a Net-AMI meter's native local services are incapable of supporting a new protocol standard due to incompatibilities with HAN network and other hardware issues. In this instance, the software is virtually performed Net-AMI but physically mapped to the cloud. The Net-AMI meter relays the information to the cloud, which processes the protocol compliant responses and communicates the formatted information packets back to the Net-AMI. Such a software defined approach requires no hardware upgrades to the net-AMI, reduces system cost reduction, and improves flexibility in the system compared with existing systems.

4.1. Cognitive Radio Model

The cloud data center offers cognitive radio applications as a spectrum management and spectrum sensing services. In regards to sensing spectrum, we propose three principal methods: matched filter detection, energy detection and feature detection. In matched filter detection services, the secondary Net-AMI users must have *a priori* knowledge of primary user's signal statistics. These methods require less detection time, but generate optimal results only when detecting stationary signals in the presence of Gaussian noise.

Alternatively, energy detection senses the spectrum by measuring the energy of the received signal in a certain time frequency band. Energy detection has very low computational complexities and can be implemented in the frequency domain by averaging FFT frequency bins; moreover, if the primary user's signal statistics are not known, energy detection can still be applied. However, it performs poorly in a low SNR environment and cannot distinguish signal, noise, and interference.

A third principal method is feature detection. The core idea involved in feature detection is to correlate with reoccurring parameters of the signal. For instance, many signals in wireless communication have a specific feature such as pilot, synchronization channels or cyclo stationary properties that we detect and classify. Feature detection can differentiate the noise energy from the modulated signal energy and works well at low SNR. However, it requires longer and more complex processing. It also needs the prior knowledge of the PU or secondary user (SU) information statistics. The longer computation time can be reduced through the use of cooperative detection. By collecting the observations from multiple cognitive radio users, we reduce detection sensitivity and detection time requirement at the expense of increased overhead and control for the cognitive radio network.

The 0-holes can be accessed by cognitive radio users. Once accessed, such time-frequency increments are labeled as 1-holes. Other SUs are prevented from using 1-holes if it is determined by the cloud data center CR scheduler that the secondary user interference reduces the system capacity. At all times, licensed band users have highest priority. The useable CR capacity depends on the licensed user network statistics.

To decrease system overhead, the interference temperature (IT) model can be used. This concept, which mitigates multiple access interference, was introduced by the FCC in order to facility the sharing of spectrum bands by SUs. Improvements in the PU's QoS results by restricting the SUs transmit power so as to make the interference at PU's receiver below the given IT threshold. However, here we pursue a constant transmit power method and instead rely on adaptive modulation and control. We make use of the method involved in the IT model. We apply the following thresholds based upon the signal-to interference-plus-noise (SINR). Outage probability is inversely proportional to the PU's QoS. During the coherence time of the channel, the IT threshold is transmitted to SUs so as to determine the PU's channel information statistics. The cloud data center cognitive services periodically broadcast a pilot signal that includes the information about its transmit power and the maximal IT threshold, *Im*.

From this, each SU can obtain the values of *Li* and *Im*. The parameter, *Li*, defines the shadowing and distance-related average channel gain between the *i*th secondary user, *SUi*, and base station (BTS). Then the practical maximal transmit power of the *SUi* (P_i^M) is constrained by both the PU's SINR outage probability and its own maximal transmit power, P_i^{Max}. In order to protect PU's QoS, we choose the maximum cognitive radio transmit power, P_i^M, restriction of the *i*th Net-AMI transmit power suggested, which is

$$P_i^M = \min\{\frac{L_m}{L_i}, P_i^{Max}\} \quad (1)$$

The term P_i^{Max} is the maximum PU power. The term $\frac{I_m}{L_i}$ is the maximum interference I_m by the primary user due to the SU co-channel interference. The SUs compete to access the shared cognitive radio channel based on their average transmit rate, we apply the practical method max throughput algorithm with proportional fair. This makes our cognitive radio cell spectrum sharing procedure "proportional fair" with the following scheduling rule metric:

$$i^* = \max_i\left(\frac{R_i^M}{T_i}\right) = \max_i\left(\frac{\log_2\left(1+\frac{(p_i^M/L_i)\|h_i\|^2}{ni+I_p}\right)}{T_i}\right).(2)$$

If the *i*th SU has interference plus noise which is *ni* + *Ip*. The optimum scheduling strategy is to schedule user *i** if their channel has the maximum rate indicated in (2) during the time period at time t, *Ti(t)*. In order to achieve fairness among SUs, the SU who has larger transmit rate and larger average throughput will not be selected, due to its larger average throughput. The parameter, *i**, is the scheduling rule, *R!* is the maximal transmit rate of *SUi*, *Li* represents the distance-dependent channel loss (>1) and shadowing effect from *SUi* to cognitive radio base station, *hi* ~ *CN*0, 1 models the normalized Rayleigh fading. *Ip* and *ni* are the background interference plus the interference caused by SUs and *i*th users background noise power, respectively. In [6], the method shows an average throughput bps/Hz is not saturated until number of secondary users is less than 120 in each cell and range of throughput bits/s/Hz is about 19 kb/s to 23 kb/s.

4.2. Net-AMI Infrastructure

The Net-AMI meter is the major component for communication of information flows in the smart grid distribution system networks. The Net-AMI meter needs to relay time of use metering, power information, HAN information for outage management, demand response, network optimization, distribution of renewable sources and controlling home or building appliances. The Net- AMI meter may not be capable of processing HAN protocols due to protocol incompatibilities issues and limited processing capabilities. The Net-AMI meter's principal architectural function is the fast communication of data to and from the cloud center. We describe how the Net-AMI meter combines all the data from various sources and hands off data to a cellular protocol for over the air communication. Eventually, data is received by the cloud system for processing. In order to process the data in the cloud in a systematic way, the Net-AMI meter appends a packet header to data to enable protocol identification and message handling.

The Net-AMI meter waits for the CTS signal from CRA for uplink transmission. The CTS signal broadcasts specific information to Net-AMI meter. The EAC header in downlink details first field as frame type. The Cloud sends CTS, query or both. This field identifies as binary 0 (CTS), query (1), and both (0, 1). The next field provides scheduling of time and frequency slots for data transfer with less interference of signals at CRA. If the Net-AMI is unable to perform transmission within a CTS timeout period, the system delays transmission until next CTS control signal. A field indicating the type of cellular protocol is included in the RF carrier frequency signal to support uplink transmission. The cloud reference time is used to account for time out scenarios based on received time slots. Finally, a Net-AMI identifier is needed for destination and source routing. Based on all these inputs, the Net-AMI meter bandpass modulates the signal to a specific RF carrier frequency and performs uplink transmission.

The Net-AMI meter concatenates an EAC header to the data packet in the EAC layer. It inserts as information packets in the cellular protocol frame. The uplink and downlink transmission of the LTE protocol are below the EAC layer. Thus, LTE applies packet retransmission to the occasional uncorrectable packet errors due to fading and path loss. This is accomplished through a highly sophisticated two layered retransmission scheme: a fast hybrid-ARQ protocol with low overhead feedback and support for soft combining with incremental redundancy. This is complemented with a highly reliable selective-repeat ARQ protocol in the MAC layer [7]. A fixed bit 24 bit cyclic redundancy check (CRC) is performed on every block coming from above layers in physical layer. The calculation performed using CRC is appended to every transport block in order to check coherence of received signal. This process ensures data integrity and allows cellular protocols to handle the issues without our intervention. Since we included the CRC in the application layer, retransmission of packets is done in network layer.

4.3. Procedures for Cloud Control Services

The cloud center is the global aggregator of services and protocols, from cognitive radio services to wave form services to energy management, to microgrid control, and many other services. The cloud data center is imbued with both baseband processor servers and general processor severs. Base band processors resemble to conventional radio network controller of the cellular service providers. Demodulation, encryption, error detection are specifically processed in baseband servers and other application oriented processes are dedicated to general purpose servers.

The structural components of the downlink cognitive radio services are spectrum management and process the cognitive radio signals from the CRA to generate a CTS signal with EAC header for downlink transmission. Moreover, cloud service supports waveform services. Processes like signal processing, error correction, baseband conversion, and other modulation techniques are designated to radio processing servers. Furthermore, radio processing servers are loaded with protocol oriented applications to process the requested services. It also provides energy home management services. These services request the necessary data from waveform services in order to monitor and analyze energy consumption, if this service has been registered or requested by the user. Similarly, if the user has renewable sources he can register with energy optimization services for optimal renewable source management. Cloud data center enables users to install any third party applications for additional services. This empowers the whole system to be flexible and extensible.

4.4. Hybrid Wireless (RF) -Fiber Optic Communication Model

We now analyze the communication link consisting of ROF, wireless signaling, and noise at the transmitter side and receiver side. We present an example Net-AMI network based ROF architecture using on external modulation for illustration. For downlink transmission from Cloud data centers to Net-AMI meters the energy services signal, $s(t)$ at power $Ps{-}Tx$ is modulated to an RF band which, in turn, is converted to an RF optical light source using an external optical modulator. This signal is carried over the downlink optical fiber where the optical signal is converted back to electrical signal using a photo detector. The Net-AMI signal is relayed to a Net-AMI meter. For uplink transmission from Net-AMI meter to cloud center, the Net-AMI signal received at the cognitive radio is converted into an optical signal by modulating a light source. It is then relayed at RF over the optical fiber relay to the cloud data center. A photo detector demodulates the optical signal to obtain electrical signal which is again demodulated using RF band to process the Net-AMI signal at the cloud data center.

The, end-to-end noise, NRx, contains both radio over fiber noise, and Nref . Due to transmission of fiber optic data to the cognitive radio base station antenna and downlink operates from the base station transmitter to the wireless Net-AMI meter. *N*rof noise is influenced by the linear amplifier after the lossy cable connecting the radio fiber optics and the base station linear amplifier after RF up-converter. The optical carrier's wavelength is usually selected to coincide with either the 1.3 mm window, which corresponds to minimum dispersion for standard single-mode fiber. Alternatively, an approximately 1.55 mm window obtains minimum attenuation and is compatible with the best-performing type of optical amplifier. Considering a single mode fiber and radio over the fiber noise, *N*rof is added at the optical receiver where the signal s(t) is weak. Considering only the dominant noise processes, the radio over fiber link noise power is sum of short noise, thermal noise and relative intensity noise (RIN) powers [8]. We now analyze uplink and downlink configurations. We can improve all the following analysis by adding additional Net-AMI receive antennas, MIMO space time codes, or increasing bandwidth.

5. HYBRID ENERGY AND BANDWIDTH MANAGEMENT FOR CLOUD DATA CENTERS

The cloud data centers are mainly designed for the wired environment. The system is designed to support data centers on wireless environment. The cognitive radio networks are used to support the data transmission on wireless mode. The cloud nodes are also operated under wireless environment. The bandwidth allocation is a complex task in the wireless cloud environment. The Net AMI infrastructure is used to support the bandwidth utilization monitoring process. The data values are relayed using the dynamically allocated bandwidth. The data and bandwidth are allocated with reference to the request basis. The system uses a cost model for bandwidth allocation process.

The cloud data center request queue and data availability details are used in the data delivery process. The energy level and bandwidth level are also considered in the transmission process. The battery power is maintained for each node. All the data delivery operations are planned with the available energy and bandwidth levels.

The system is divided into five major modules. They are cloud data center, bandwidth allocation, price management, client and data request process. The cloud data center module is designed to provide shared data for the data owners. The bandwidth allocation module is designed to assign bandwidth for data transmission process. The price management module is designed to assign price for data and bandwidth usage levels. The client module is designed to perform data access process. The data delivery module is designed to download the data values from the data centers.

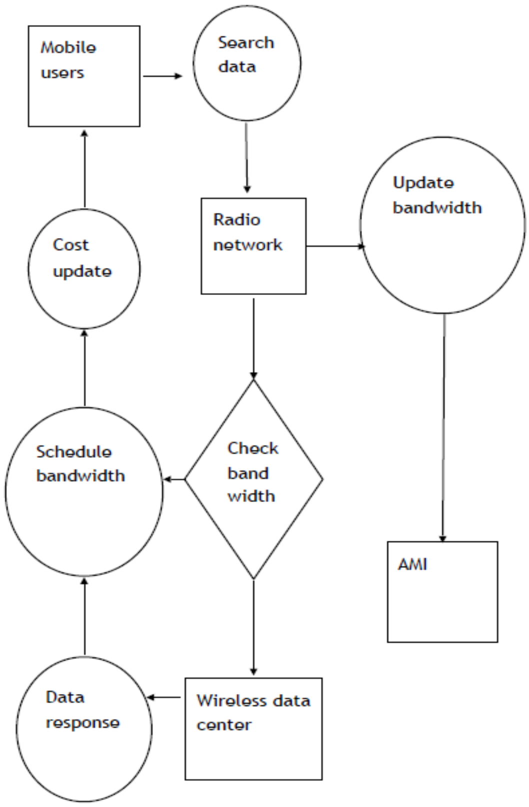

Fig 1: *Energy and Bandwidth Management Model for Wireless Clouds*

5.1. Cloud Data Center

Cloud data center module is designed to maintain the shared data values. The data values are provided for the wireless cloud nodes. The cloud nodes requests are collected by the data center. The data center send the response based on the available bandwidth energy levels. The data values can be dynamically updated by the provider.

5.2. Bandwidth Allocation

The cognitive radio networks are used for the wireless communication process. Data rates, ranges, and capacity of the cognitive radio for relatively low 1W uplink and 10Watt downlink configurations reveal highly reliable data rate configurations from 1–3 km, with a possibility of trading off additional range versus data rate. The bandwidth allocation process is designed to allocate bandwidth for the cloud nodes. The bandwidth is divided for the requested nodes.

5.3. Price Management

The price management module is designed to estimate the price for the bandwidth and data usage levels. The Net AMI is used to measure the bandwidth usage details. The bandwidth price and data usage price are decided by the data center. The priority factor is also used to decide the price values. The high priority data delivery is charged with high price values.

5.4. Client

The client module is designed to collect shared data from the cloud data centers. The client collects the shared data files list from the data center. The data values are transferred from the data center. The data files are downloaded from the data center and updated into the client system.

5.5. Data Request Process

The data request process is designed for the client application. The data request is submitted with data file name and its priority values. The price estimation is performed for the request. The data delivery process is started after the completion of bandwidth allocation process. The bandwidth and energy usage is monitored and updated by the Net AMI environment.

6. CONCLUSION

Cloud data center manages and distributes the shared data for the cloud users. Wireless communication methods are supported by cognitive radio networks. Net-AMI (Netbook Advance Metering Infrastructure) is used to share data centers under wireless environment. Pricing and energy management models are used to improve the wireless communication models. The system manages data centers with energy constraints. The system monitors the bandwidth usage levels. The system improves the bandwidth sharing in wireless communication process. Transmission process is adjusted with traffic conditions.

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